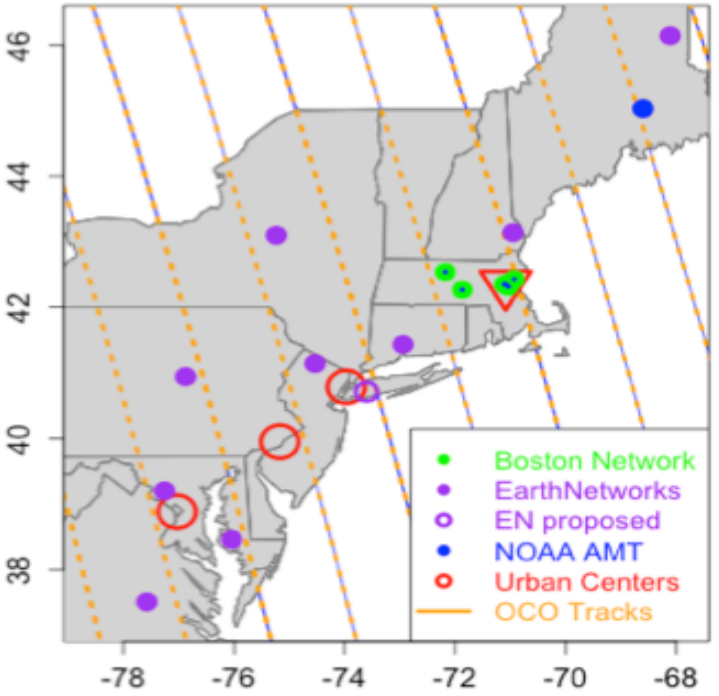
Progress towards regional scale carbon monitoring atmospheric validation: Year 1 results for the Northeast Corridor

- Objective:
  - downscale the current NASA CMS flux products to the regional and local scales pertinent to Monitoring, Reporting, and Verification (MRV)
- Approach:
  - focus on the Boston-DC megalopolis corridor
    - 17% of the U.S. population, less than 2% of the land area
  - design a measurement network
  - develop an atmospheric modeling framework
  - High-resolution transport modeling
    - Mesoscale atmospheric model (WRF) coupled to Lagrangian particle dispersion model (STILT)
    - Verification includes PBL data from lidar profilers (**MiniMPL)**
  - High-resolution CO2 flux model incorporating
    - anthropogenic emissions estimates and the
    - CASA model (including its 0.5-deg resolution variant)
  - Inverse CO2 flux estimates



Prototype Monitoring, Reporting and Verification System for the Regional Scale: The Boston-DC Corridor

Institutions involved:

Organization	Institutional PI	Project Role
Atmospheric and Environmental Research	Thomas Nehrkorn	PI, meteorological modeling and verification, transport modeling, flux inversion
Harvard University	Steven C. Wofsy	Co-I, Boston measurements, flux inversion
Boston University	Lucy Hutyra	Co-I, *a priori* anthropogenic and biosphere flux models
Goddard Space Flight Center	G. James Collatz	Co-I, CASA-GFED biosphere fluxes at 0.5˚ and downscaling
Sigma Space	Philip L. DeCola	Co-I, Mini MPL deployment, operation, and data analysis
Earth Networks	William J. Callahan	Co-I, Tower Measurements of CO_2 and other greenhouse gases
Jet Propulsion Laboratory	Charles E. Miller	Collaborator, OCO-2 analysis
University of Massachusetts, Boston	Crystal Schaaf	Collaborator, Analysis of UMass Boston data

Observation Network Activities

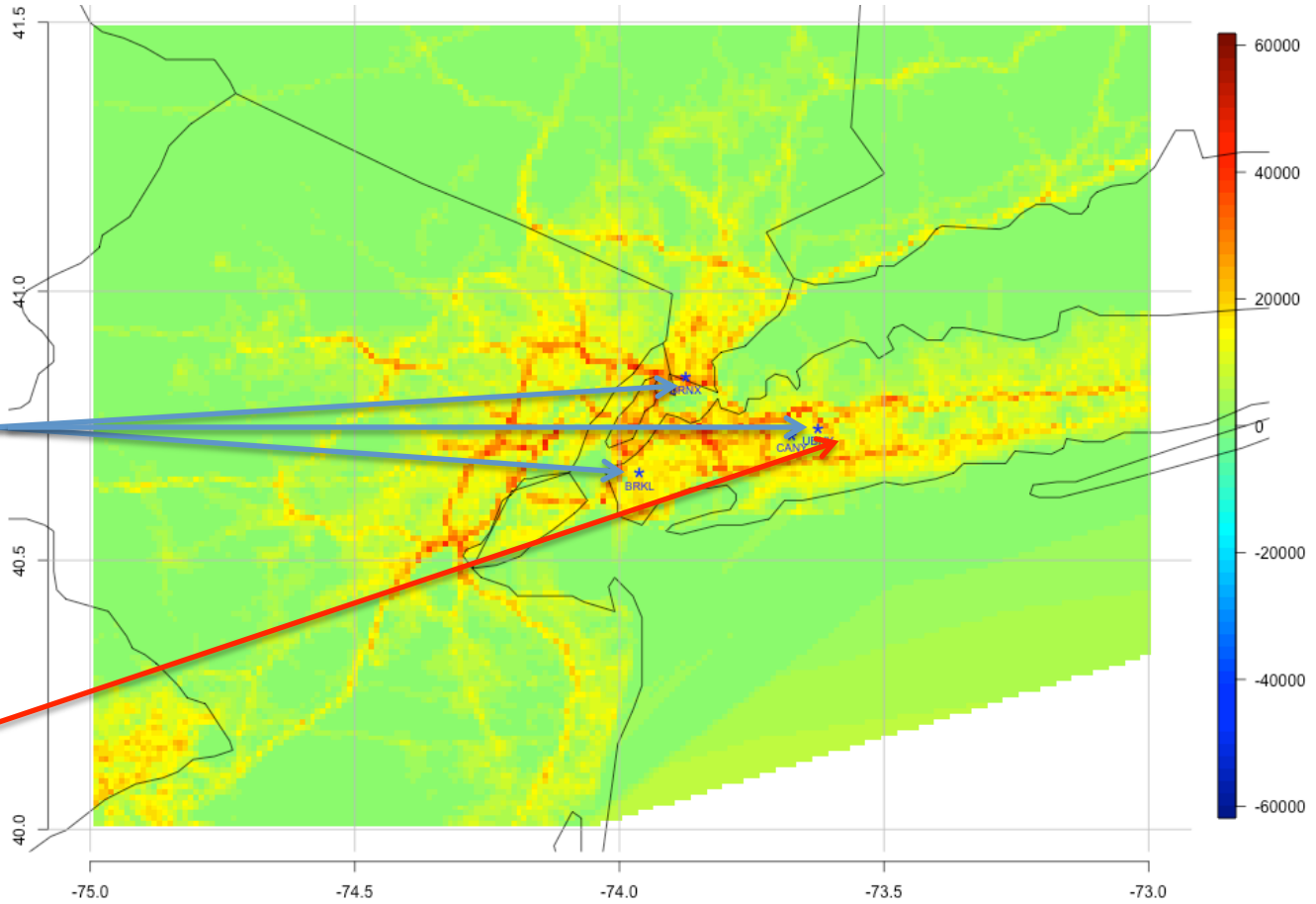
- Cross-calibration of Boston and Earth Networks GHG sensors
  - Compare measurements using Harvard and Earth Networks calibration gas tanks
  - Agreement to within 0.01 – 0.02 ppm
- Installation of new GHG tall-tower site on Long Island, NY
  - Site selection based on WRF-STILT sensitivity analysis
- Deployment of mini Micro Pulse Lidar (miniMPLs) collocated with GHG sensors:
  - Long Island tower
  - Upwind location (Lewisburg, PA)
- Real-time acquisition of GHG and miniMPL data

Placement of new tall-tower GHG on Long Island

Map of traffic-related CO_2 emissions

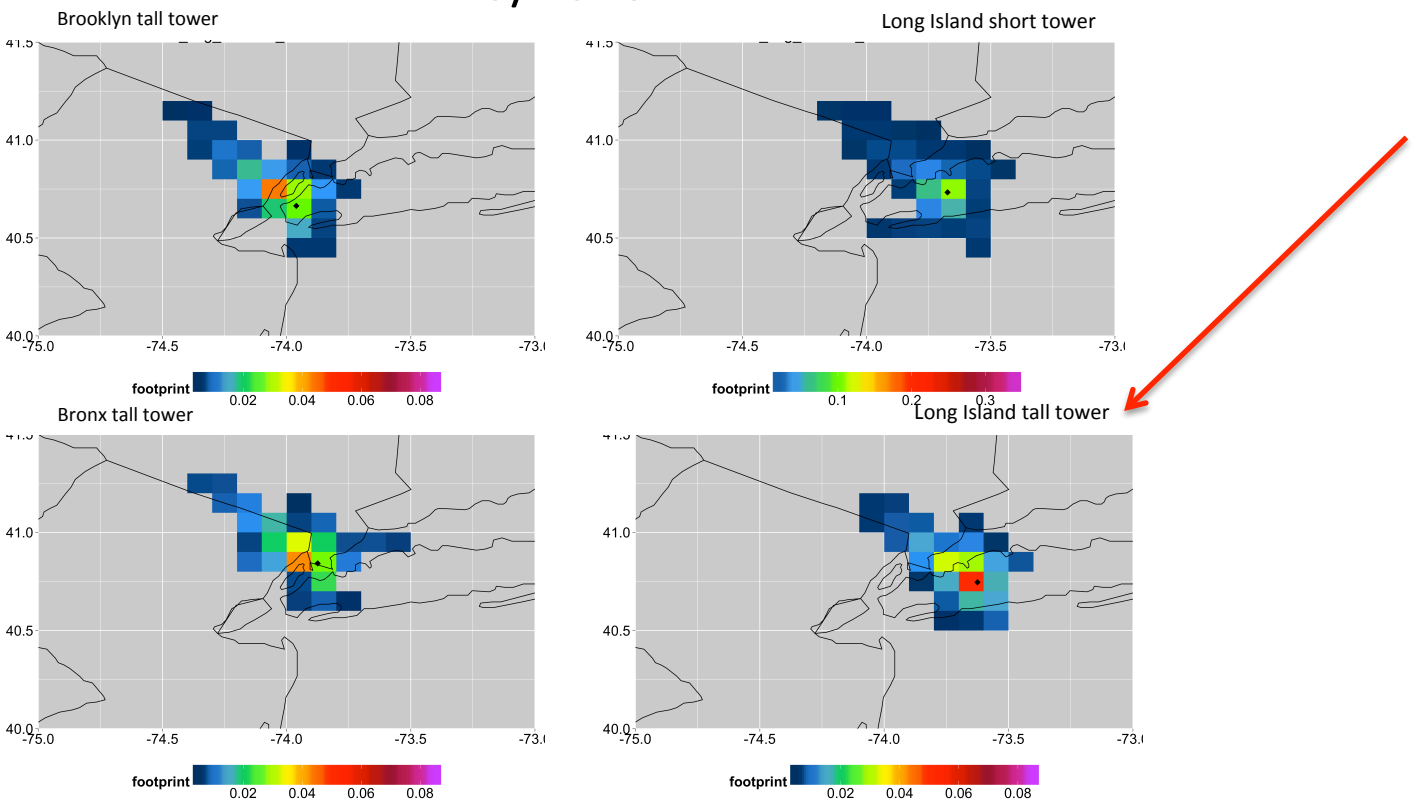
Candidate sites

Final site



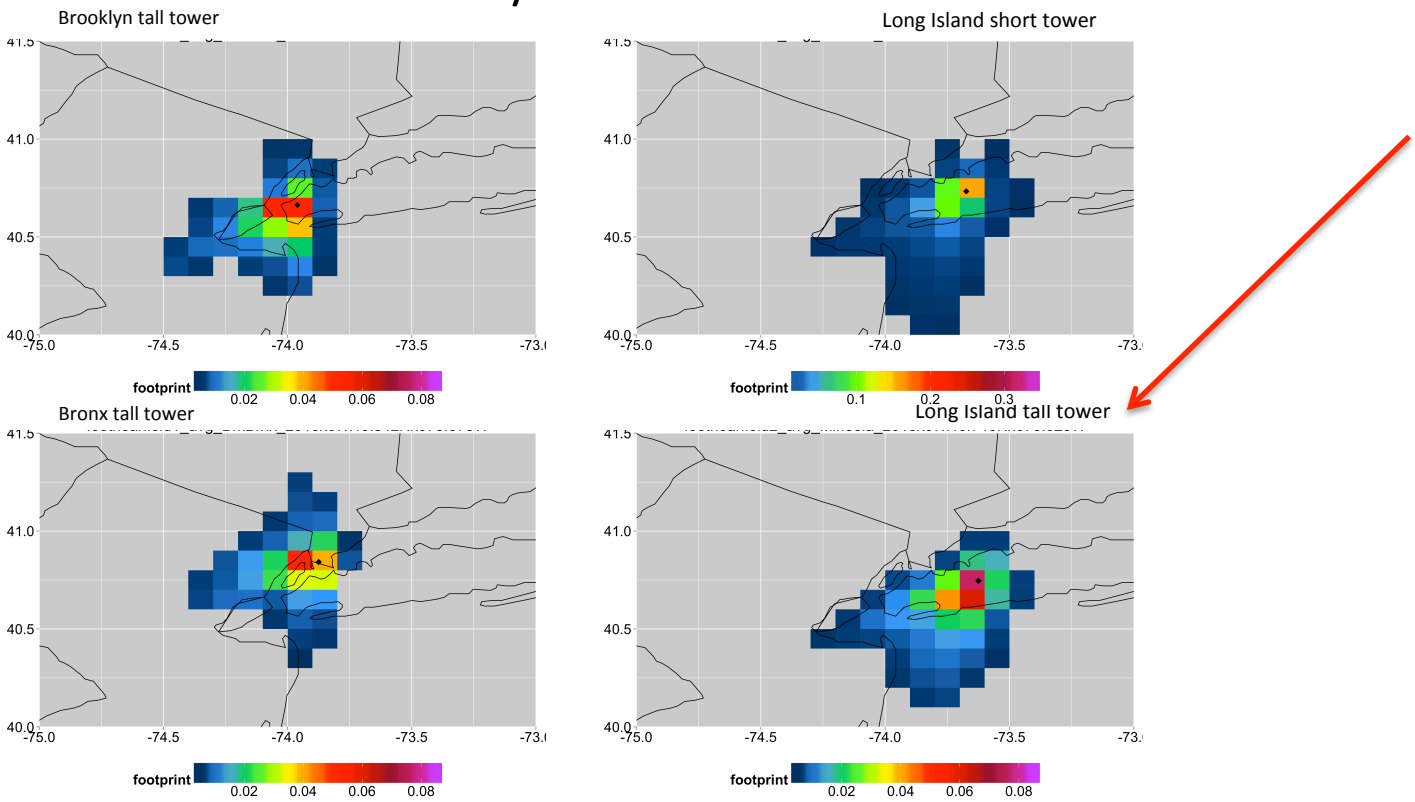
Analysis of tower sensitivity for candidate sites

3/2013



Analysis of tower sensitivity for candidate sites

7/2013



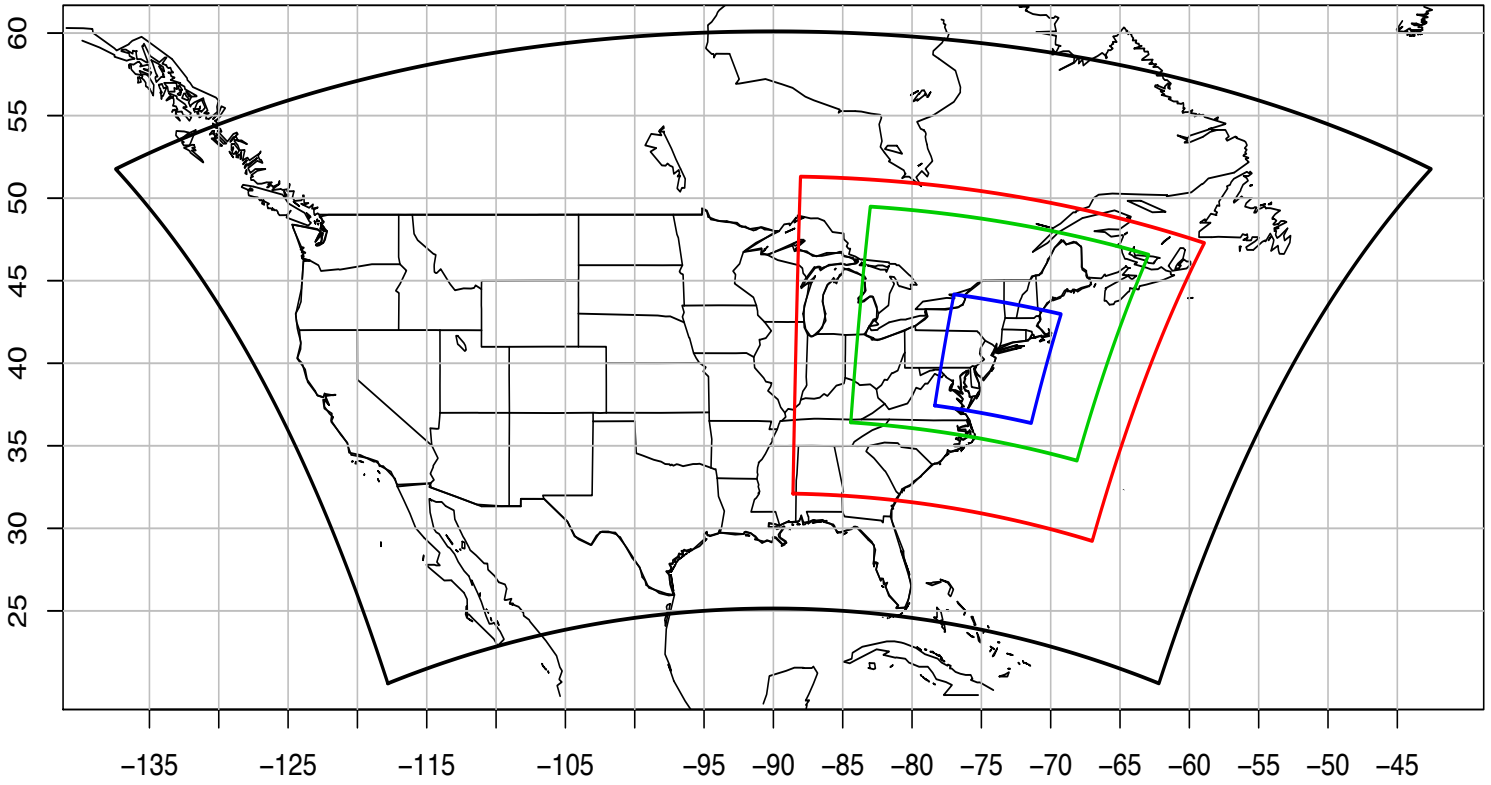
Long Island tower

Atmospheric Modeling Framework

- WRF configuration
- WRF model performance evaluation
  - CH4 study for Boston
  - diurnal cycle diagnostics
  - miniMPL <-> WRF PBL comparisons
- Sensitivity studies
  - Controlled tracer experiments for urban area

WRF Modeling

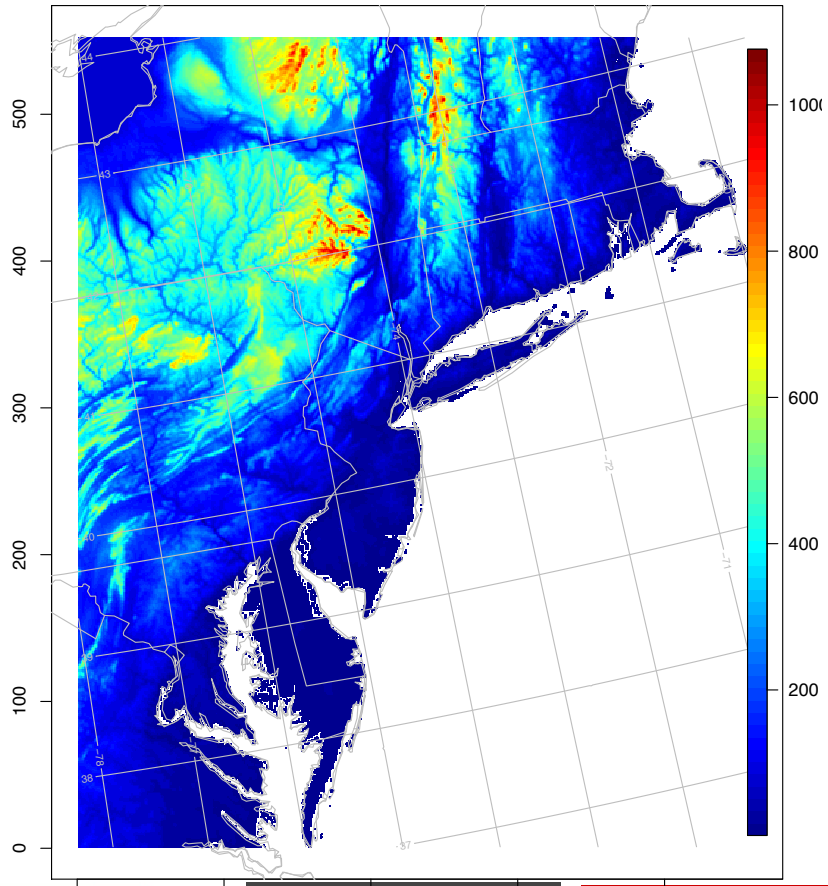
- Modeling framework: WRF model setup for corridor simulations
  - Nested (36km / 12km / 4km / 1.33km resolution) domains
  - Inner-most domain includes an urban canopy parameterization



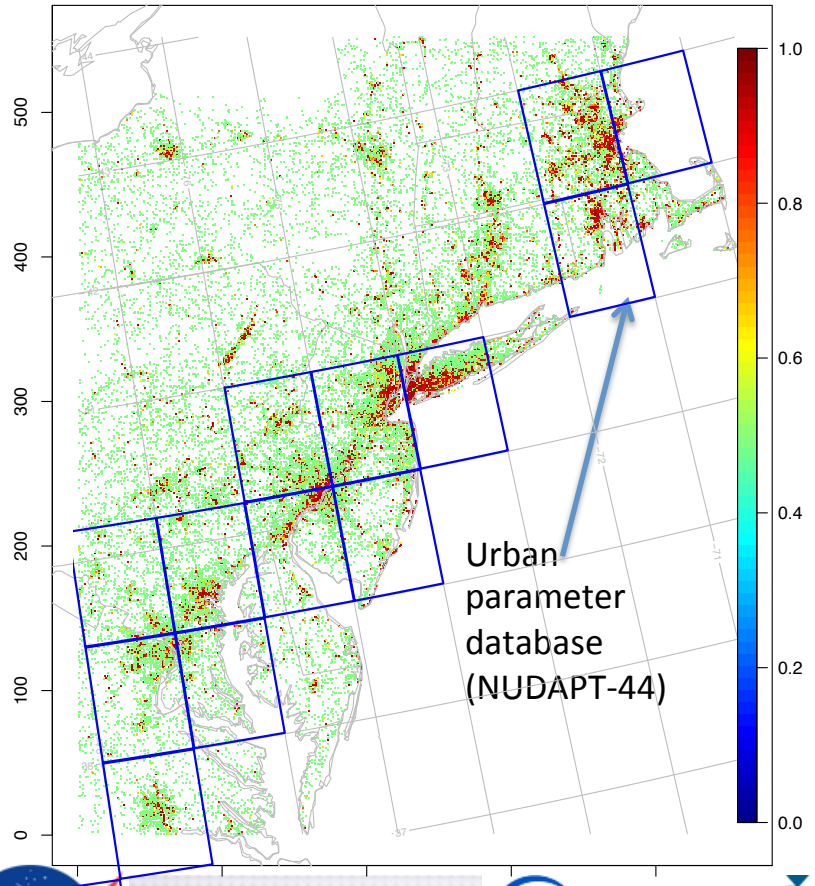
WRF Modeling

1.33km resolution domain

odel terrain height



urban fraction



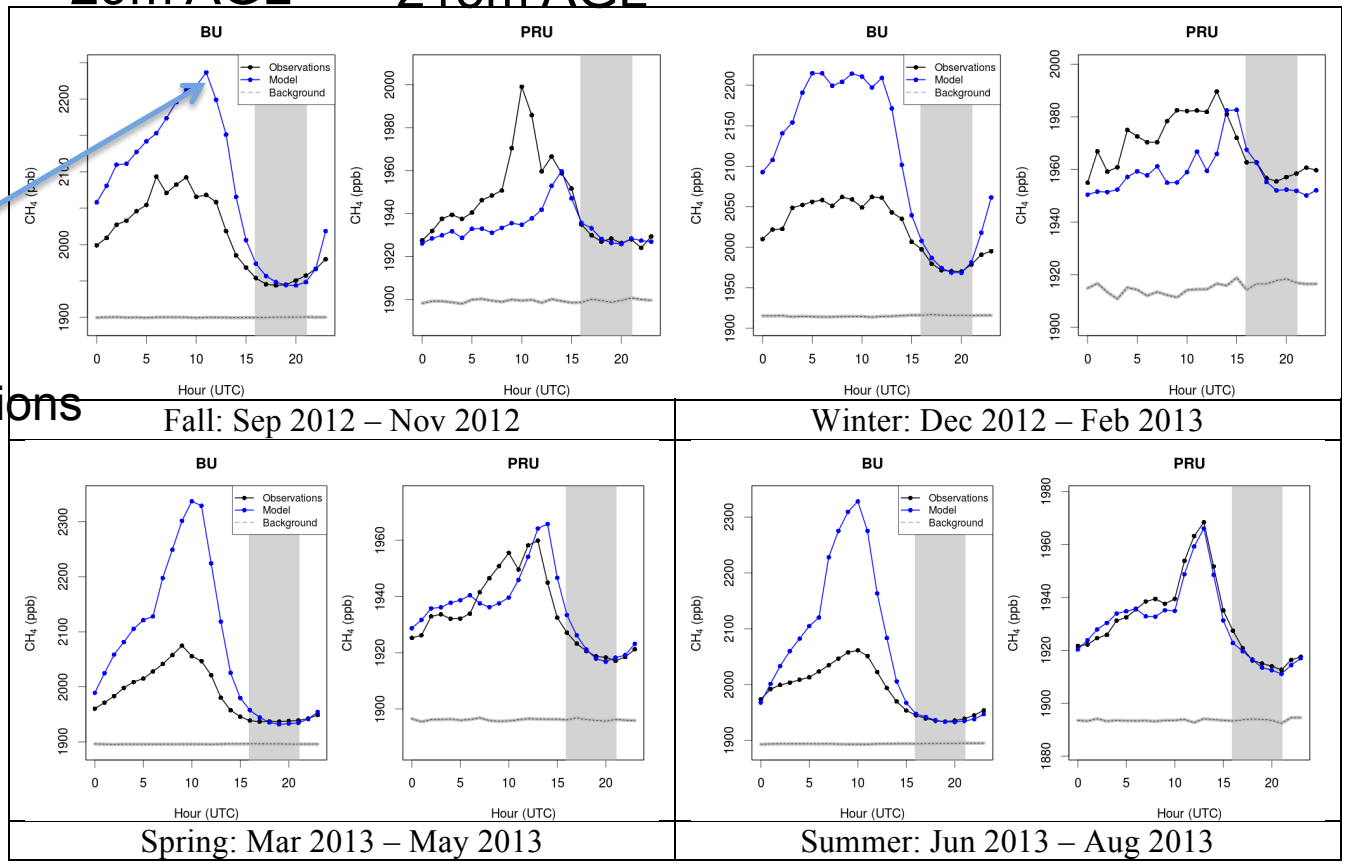
WRF model evaluation – diurnal cycle diagnostics

- CH_4 study for Boston
  - Uses Boston observation network, similar modeling framework

BU site: 29m AGL

Pru site: 215m AGL

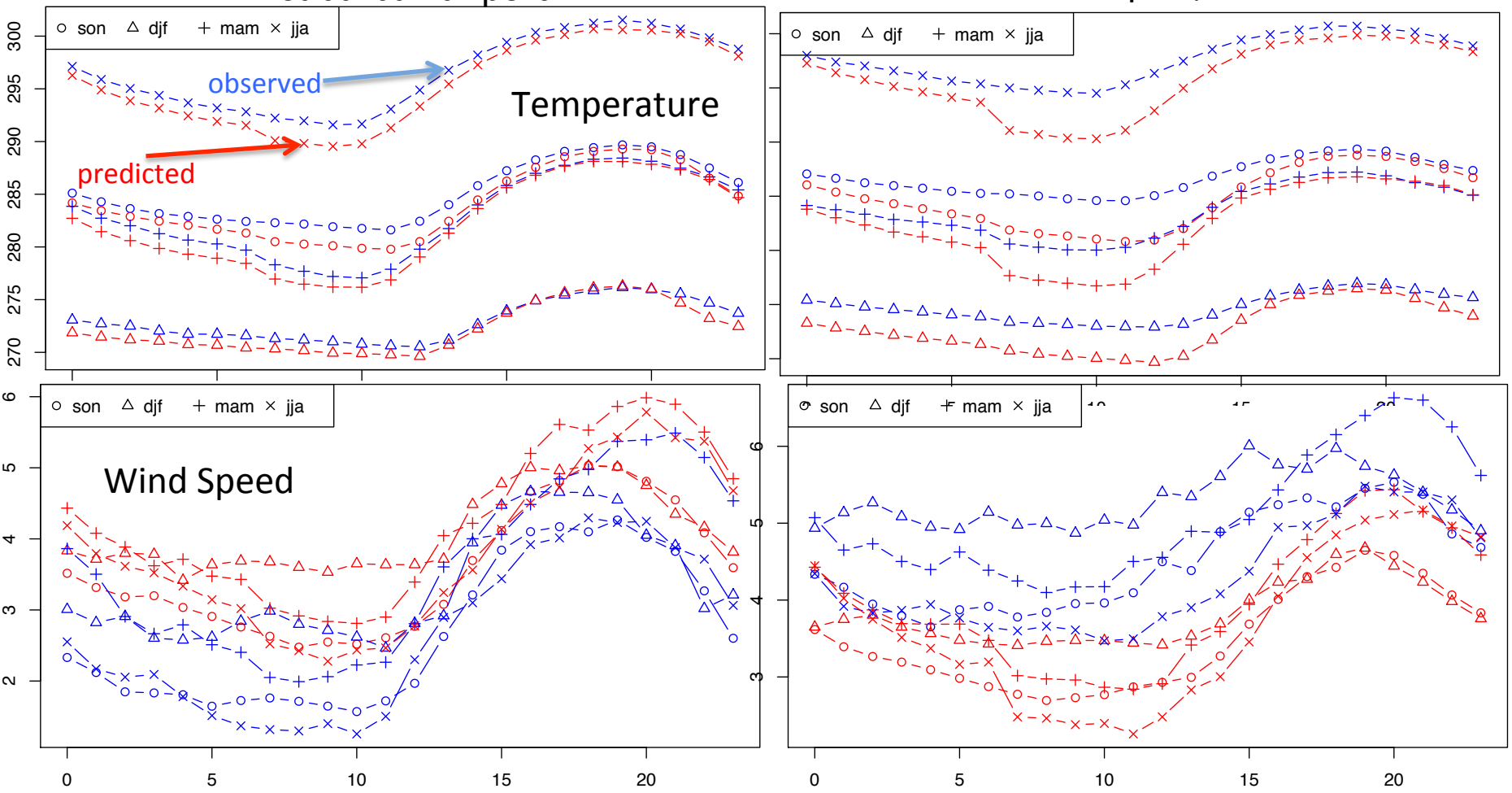
Simulated nighttime concentrations too high



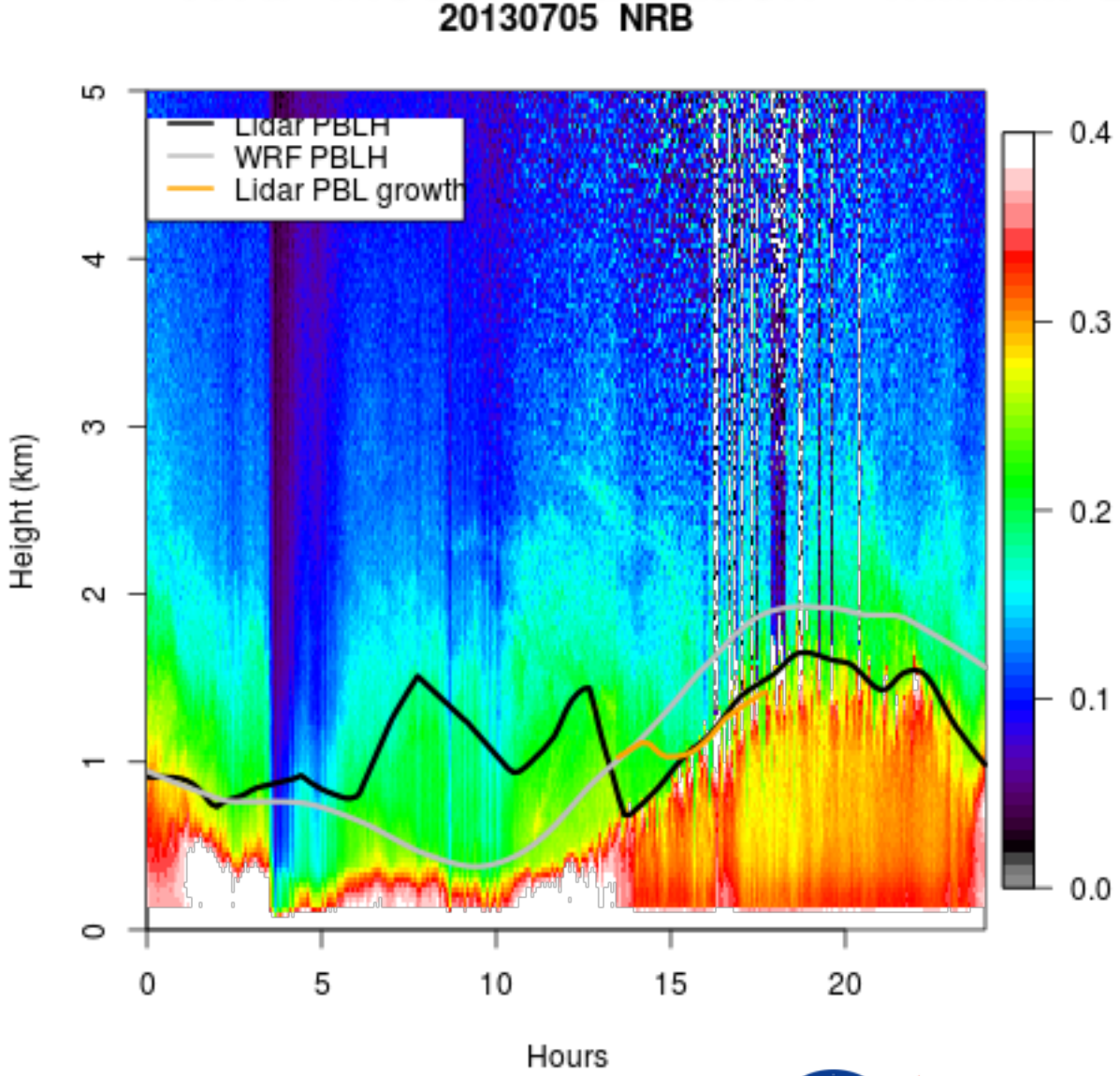
- Mean diurnal cycle of temperature and wind speed
- Overpredicted nighttime stability (➔PBL scheme, sfc scheme, …)
- High wind speed bias over land at all hours (➔ WRF upgrades)

KBED: suburban airport

KBOS: urban airport/harbor



WRF model evaluation – miniMPL PBL height

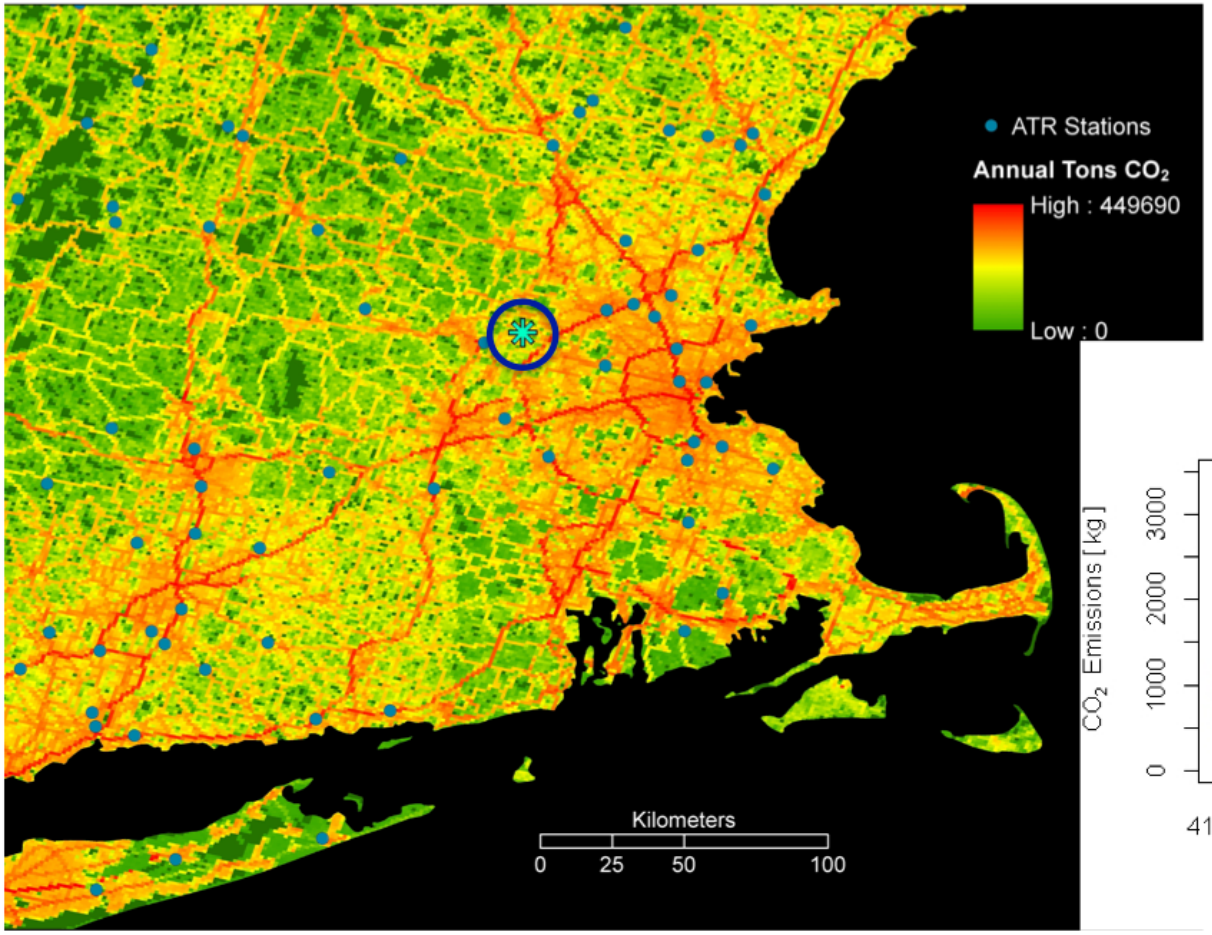


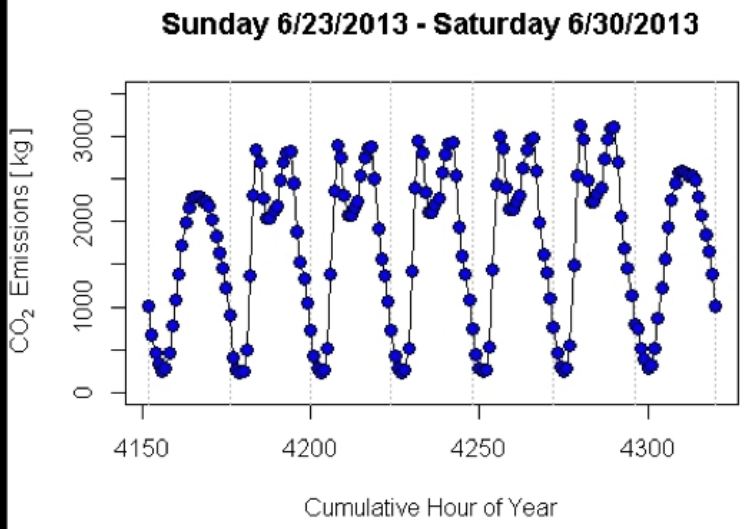
Poster: comparison with CAILPSO data

Flux Modeling Framework

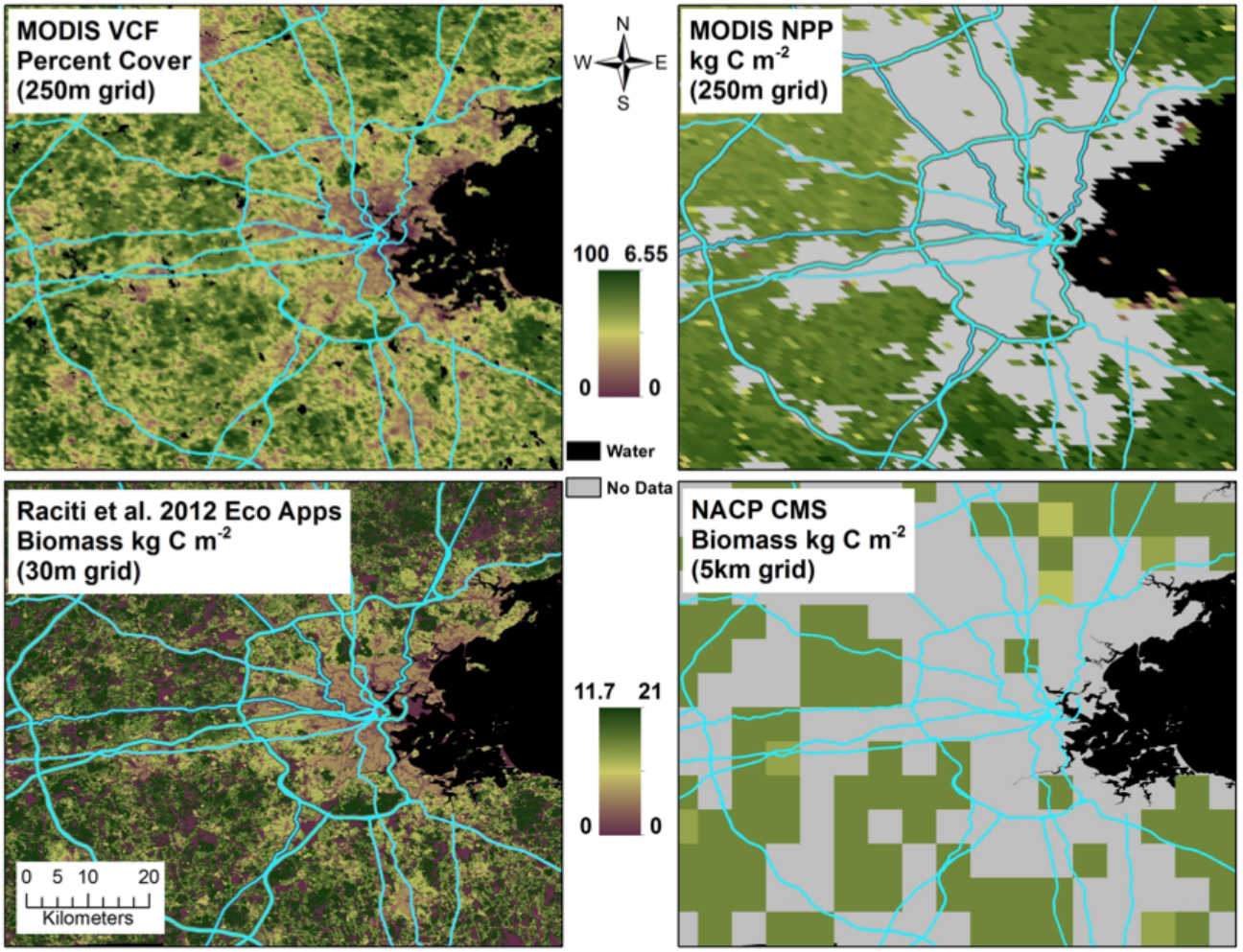
- High resolution *a priori* flux estimates
  - Combine sources of information with high spatial and/or temporal resolution
  - Include estimates of biogenic fluxes in and near urban areas

Flux modeling: FFCO2





Flux modeling: Biosphere



- While urban biomass pools are reduced, they are far from zero and will influence atmospheric mixing ratios.
- New urban vegetation productivity data suggests ~2x the ecosystem productivity per unit biomass due to urban growing conditions.

Next steps:

- Observing Network
  - Continued monitoring of GHG sites
  - miniMPL data analysis and comparison with CALIPSO data
- Modeling Framework
  - WRF sensitivity studies
  - miniMPL <-> WRF PBL comparisons
  - WRF-STILT footprint computations for Observing network sites
    - Baseline period: July 2013 – July 2014
    - Enhanced coverage: baseline + Long Island tower (starting Apr 2014) + OCO-2 (2015) + FTS (Boston)
  - Flux modeling: refinements of initial baseline estimates
- Top-down inversions